

FORM PTO-1396
(REV. 1-98)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

ATTORNEY'S DOCKET NUMBER

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

246.1358

U.S. APPLICATION NO. (if known, see 37 CFR 1.5)

09/701121

INTERNATIONAL APPLICATION NO.

INTERNATIONAL FILING DATE

PRIORITY DATE CLAIMED

PCT/B99/00866

May 14, 1999

May 22, 1998

TITLE OF INVENTION MONOMER PROTEIN WITH BONE MORPHOGENETIC ACTIVITY AND
MEDICINAL AGENT CONTAINING THE SAME FOR PREVENTING AND TREATING DISEASES OF

APPLICANT(S) FOR DO/EO/US CARTILAGE AND BONE
KAWAI et al


Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a FIRST submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☐ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2)) IN ENGLISH
 - a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau).
 - b. ☐ has been transmitted by the International Bureau.
 - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
 - a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
 - b. ☐ have been transmitted by the International Bureau.
 - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
 - d. ☐ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)). UNEXECUTED
10. ☐ A translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.
 - ☐ A SECOND or SUBSEQUENT preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information: International Preliminary Examination Report

529 Rec'd PCT/PTC 20 NOV 2000

U.S. APPLICATION NO. 097701121		INTERNATIONAL APPLICATION NO. PCT/IB99/00866		ATTORNEY'S DOCKET NUMBER 146.1358	
17. <input checked="" type="checkbox"/> The following fees are submitted: BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)): Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO \$1070.00 International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO \$930.00 International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO \$790.00 International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) \$720.00 International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) \$98.00 ENTER APPROPRIATE BASIC FEE AMOUNT =				CALCULATIONS PTO USE ONLY \$1000.00	
Surcharge of \$130.00 for furnishing the oath or declaration later than months from the earliest claimed priority date (37 CFR 1.492(e)). <input type="checkbox"/> 20 <input type="checkbox"/> 30				\$	
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	\$	
Total claims	-20 =		x \$22.00	\$	
Independent claims	-3 =		x \$82.00	\$	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)				+ \$270.00 \$	
TOTAL OF ABOVE CALCULATIONS =				\$	
Reduction of 1/2 for filing by small entity, if applicable. A Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28).				+	
SUBTOTAL =				\$1000.00	
Processing fee of \$130.00 for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				\$	
TOTAL NATIONAL FEE =				\$1000.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40.00 per property +				\$	
TOTAL FEES ENCLOSED =				\$1000.00	
				Amount to be refunded: \$	
				charged: \$	
a. <input checked="" type="checkbox"/> PTO Form 2038 is enclosed. A check in the amount of \$_____ to cover the above fees is enclosed.					
b. <input type="checkbox"/> Please charge my Deposit Account No. _____ in the amount of \$_____ to cover the above fees. A duplicate copy of this sheet is enclosed.					
c. <input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. <u>02-2275</u> A duplicate copy of this sheet is enclosed.					
NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.					
SEND ALL CORRESPONDENCE TO: Bierman, Muserlian and Lucas 600 Third Avenue New York, NY 10016					
			SIGNATURE <u>Charles A. Muserlian</u> NAME <u>Charles A. Muserlian</u> 19,683 REGISTRATION NUMBER		
20311 PATENT, TRADEMARK OFFICE					

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OFFI

#6

PCT Date: May 14, 1999

600 Third Avenue
New York N.Y. 10016
November 22, 2000

SEQUENCE LISTING

Asst. Commissioner for Patents
Washington, D.C. 20231

Sir:

Applicants are submitting herewith a paper copy of the sequence listing as well as an amendment directing its entry into the specification. Also filed is an initial computer readable form disc (CRF) copy of the sequence listing. The content of the paper and computer readable disc are the same and where applicable, include no new matter as required by 37 C.F.R. 1.821(e) or 1.821(f) or 1.821(g) or 1.825(b) or 1.825(d). It is believed that Applicants have now complied with the sequence listing rules.

Respectfully submitted,
Bierman, Muserlian and Lucas

By:

Charles A. Muserlian #19,683
Attorney for Applicants
Tel.# (212) 661-8000

CAM:ds
Enclosures



11-21
NA

527 Re PCT/PTO 20 NOV 2000

146.1358

Not in Crosswalk
09701121

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	:	PCT Date: May 14, 1999
S. KAWAI et al	:	
PCT No.: PCT/IB99/00866	:	
Filed: Concurrently Herewith	:	
For: MONOMER...CARTILAGE AND BONE	:	

600 Third Avenue
New York N.Y. 10016

PRELIMINARY AMENDMENT

Asst. Commissioner for Patents
Washington, D.C. 20231

Sir:

Please amend this application as follows:

IN THE SPECIFICATION:

Page 1, before 1, insert

--This application is a 371 of PCT/IB99/00866 filed May 14,
1999.--

IN THE CLAIMS:

Claim 3, line 1, cancel "or 2"

Claim 5, line 4, cancel "any one of claims 1 to 4" and insert

--claim 1--

Claim 6, lines 1 and 2, cancel "any one of claims 1 to 4" and
insert --claim 1--

PLEASE ADD THE FOLLOWING CLAIM:

--11. A method of treating osteoporosis in warm-blooded
animals comprising administering to warm-blooded animals an
effective amount of a monomer protein of claim 1 sufficient to

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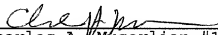
treat osteoporosis.

12. A method of treating osteoporosis in warm-blooded animals comprising administering to warm-blooded animals an effective amount of a monomer protein of claim 4 sufficient to treat osteoporosis.--

REMARKS

The amendment is filed to insert reference to the PCT application, to remove multiple dependency from the claims and to add method of use claims.

Respectfully submitted,
Bierman, Muserlian and Lucas

By: 
Charles A. Muserlian #19,683
Attorney for Applicants
Tel.# (212) 661-8000

CAM:ds
Enclosures

09701121.010301



146.1358

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: : PCT Date: May 14, 1999
S. KAWAI et al :
PCT No.: PCT/IB99/00866 :
Filed: November 20, 2000 :
For: MONOMER...CARTILAGE AND BONE :

600 Third Avenue
New York N.Y. 10016
November 22, 2000

AMENDMENT

Asst. Commissioner for Patents
Washington, D.C. 20231

Sir:

Applicants are submitting herewith a paper copy of the
sequence listing for the above application and it is requested that
the same be inserted into the application.

Respectfully submitted,
Bierman, Muserlian and Lucas

By: Charles A. Muserlian
Charles A. Muserlian #19,683
Attorney for Applicants
Tel.# (212) 661-8000

CAM:ds
Enclosures

09701121.010301

#6

PCT/IB99/00866 PCT Date: May 14, 1999 Filed: Nov. 20, 2000

S. KAWAI, et al



SEQUENCE LISTING

<110> Hoechst Marion Roussel

<120> Novel monomer protein with bone morphogenetic activity
and medicinal agent containing the same for preventing
and treating diseases of cartilage and bone.

<130> JH98K008 PCT SEQUENCES IN ENGLISH

<140>

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<150> 10-141379

<151> 1998-05-22

<160> 4

<170> PatentIn Ver. 2.1

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<211> 357

<212> DNA

<213> HUMAN

<220>

<221> CDS

<222> (1)..(357)

<223> Relevant amino acid residues in SEQ ID NO 1 from 1
to 82 and from 84 to 119 in WO 95/04819.

Note : aminoacid residue 83 is alanine
instead of cysteine.

<300>

<301> HOTTEN, Gertrud
NEIDHARDT, Helge
PAULISTA, Michael

<302> New growth/differentiation factor of the tgfbeta
familie.

<310> WO 95/04819

<311> 1995-02-16

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1				5				10					15			

cgc	tgc	agt	cgg	aag	gca	ctg	cat	gtc	aac	ttc	aag	gac	atg	ggc	tgg	96
Arg	Cys	Ser	Arg	Lys	Ala	Leu	His	Val	Asn	Phe	Lys	Asp	Met	Gly	Trp	
		20					25						30			

gac	gac	tgg	atc	atc	gca	ccc	ctt	gag	tac	gag	gct	ttc	cac	tgc	gag	144
Asp	Asp	Trp	Ile	Ile	Ala	Pro	Leu	Glu	Tyr	Glu	Ala	Phe	His	Cys	Glu	
		35					40					45				

ggg	ctg	tgc	gag	ttc	cca	ttg	cgc	tcc	cac	ctg	gag	ccc	acg	aat	cat	192
Gly	Leu	Cys	Glu	Phe	Pro	Leu	Arg	Ser	His	Leu	Glu	Pro	Thr	Asn	His	

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60

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85 90 95

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Gly Leu Cys Glu Phe Pro Leu Arg Ser His Leu Glu Pro Thr Asn His
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Ala Val Ile Gln Thr Leu Met Asn Ser Met Asp Pro Glu Ser Thr Pro
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Pro Thr Ala Cys Val Pro Thr Arg Leu Ser Pro Ile Ser Ile Leu Phe
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37

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MONOMER PROTEIN WITH BONE MORPHOGENETIC ACTIVITY AND MEDICINAL AGENT CONTAINING THE SAME FOR PREVENTING AND TREATING DISEASES OF CARTILAGE AND BONE

5 BACKGROUND OF THE INVENTION

(1) Field of the Invention

The present invention relates to a monomer protein having an amino acid sequence belonging to TGF- β superfamily, of which cysteine related to a dimer formation of a protein
10 has been replaced with another amino acid. Moreover, the present invention relates to a method for preparing said monomer protein in a large amount and with a high purity by using *Escherichia coli* transformed with a plasmid containing a DNA sequence that can express said monomer protein.

15 Furthermore, the present invention relates to an agent containing said monomer protein for preventing and treating a disease affecting bone and/or cartilage.

(2) Description of the Related Art

Currently, there are known estrogen, calcitonin, vitamin
20 D3, its derivatives and derivatives of bisphosphonic acid as preventive or therapeutic agents for bone diseases. Recently, it has been reported that a bone morphogenetic activity is found in a series of a bone morphogenetic protein (hereinafter referred to as "BMP") belonging to TGF- β
25 superfamily, from BMP-2 to BMP-14.

Moreover, it has been reported that a protein named GDF-5 or human MP52 has a bone morphogenetic activity (WO93/16099, WO95/04819, WO94/15949 and Nature Vol. 368, 1994, p. 639-643). It is considered that mature human MP52
30 is a protein having 120 amino acid residues starting with alanine at an N-terminal, and its amino acid sequence has been described in these patent applications.

These proteins exist as a homodimer having a single disulfide bond in nature. On the contrary, the manufacture
35 of their recombinant protein is carried out using their homodimers or heterodimers to yield a protein showing the activity. For example, human MP52 has been reported in the publication of unexamined application, JP 031098/97.

Meanwhile, there are two types named type I receptor and type II receptor in the receptors of TGF- β superfamily.

Intercellular signal transmission via receptors of TGF- β superfamily containing these bone morphogenetic proteins

- 5 (dimers) requires simultaneous combination of these proteins to both type I and type II receptors, and it is considered that a polymer is formed by gathering of two or more dimers to do intercellular signal transmission (Bone, Vol. 19, 1996, p. 569-574). It has been considered that for polymer
10 formation it is important that the protein should be a dimer. The activity in a monomer has not yet been found. Moreover, preparation for these monomer recombinants has not yet been carried out.

SUMMARY OF THE INVENTION

- 15 The present inventors have attempted a mass production of human MP52 monomers by a genetic engineering technology using *Escherichia coli*. Namely, the present inventors constructed a plasmid of DNA sequence encoding the amino acid sequence having 119 residues described in SEQ ID NO: 1 of the
20 Sequence Listing, among which the codon of the cysteine residue of No. 83, that is related to a disulfide bond between MP52 monomer molecules, was converted to the codon of alanine. In addition, the inventors have succeeded in expressing a large amount of human MP52 monomers using
25 *Escherichia coli* by using the plasmid and refolding to produce monomers of the protein described in SEQ ID NO: 1 of the Sequence Listing with a high purity and a very high yield.

- It has been surprisingly found that the monomer has the
30 activity to induce differentiation to osteocytes in some cell lines (MC3T3-E1 and ATDC5) despite that in conventional understanding, only a dimer has a bone morphogenetic activity. The present invention has been completed by observing that the activity to induce differentiation is two-
35 fold higher than that of the dimer on the basis of weight concentration.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a plasmid map of the expression vector

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(pKOT279) obtained in Example 1 (2).

Fig. 2 is a comparative figure of osteoblast differentiation promoting activities between the monomer of the present invention and human MP52 dimer. (A) shows the activity in MC3T3-E1 cells and (B) shows that in ATDC5 cells. The white circle shows the activity of the monomer and the black circle shows that of human MP52 dimer.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Namely, the present invention relates to a monomer protein having an amino acid sequence belonging to TGF- β superfamily, of which cysteine related to a dimer formation of the protein has been replaced with another amino acid, a method for expressing said monomer protein, and an agent for preventing and treating a disease affecting bone and/or cartilage containing one or more than one said monomer proteins.

The present invention relates to a monomer protein having an amino acid sequence belonging to TGF- β superfamily, of which cysteine related to a dimer formation of the protein has been replaced with another amino acid. The TGF- β superfamily of the present invention means BMP-2, BMP-4, BMP-5, BMP-6, BMP-7, BMP-12, BMP-13, BMP-14, human MP52, GDF-5, GDF-6, GDF-7, etc. Another amino acid may be any amino acid selected from a group consisting of alanine, threonine, serine and valine in consideration of the size of an amino acid side chain. The most preferable amino acid is alanine.

The present invention relates to a monomer protein having an amino acid sequence described in SEQ ID NO.: 1 of the Sequence Listing. In detail, the monomer protein is a protein in which cysteine is replaced with alanine, and the aforesaid cysteine contributes to intermolecular disulfide bond of a human MP52 dimer having an intermolecular disulfide bond, and is present at the 83rd position of the amino acid sequence of SEQ ID NO.: 1 of the Sequence Listing. The monomer protein obtained by the present invention shows a two-fold higher activity in inducing differentiation than a dimer protein made from the monomer protein.

Furthermore, the present invention relates to a method for preparation of said monomer protein to express by using *Escherichia coli*, yeast, insect cells, and mammal cells that have been transformed by a plasmid having a DNA sequence capable of expression of said monomer protein. In detail, the present invention relates to a method for preparation of a protein having 119 amino acid residues derived from human MP52 represented by SEQ ID NO.: 2 of the Sequence Listing, by employing *Escherichia coli*. In other words, the present invention relates to construction of a plasmid having a DNA sequence that encodes an amino acid sequence in which methionine is added to the N-terminal of the amino acid sequence derived from human MP52 in which alanine has replaced cysteine of the 83rd position from 119 residues represented by SEQ ID NO.: 1 of the Sequence Listing. For human MP52 cDNA, a mature portion was solely amplified by polymerase chain reaction (PCR method) by using a plasmid vector as a template DNA containing cDNA described in WO93/16099. The PCR method used in the invention means general amplification from a very small amount of a fragment of DNA or RNA of a nucleic acid by the method described in USP 4,683,195.

In the present invention, a mutant monomer protein was obtained by construction of a plasmid having a DNA sequence that encodes an amino acid sequence in which methionine is added to the N-terminal of the amino acid sequence represented by SEQ ID NO.: 1 of the Sequence Listing, by transformation of the plasmid to *Escherichia coli*, by solubilization of the inclusion body obtained by culturing the *Escherichia coli* and by purification. The present invention relates to a method for preparation of the protein by refolding to have an activity and purifying said protein to a monomer protein described in SEQ ID NO.: 2 of the Sequence Listing. Concretely, for the monomer protein of the present invention, MP52 mutant monomer protein was obtained by applying the solubilized inclusion bodies of *Escherichia coli* to a SP-Sepharose FF column (Amersham Pharmacia Biotech) and to Superdex 200 pg column (Amersham Pharmacia Biotech).

Subsequently, the purified monomer protein of the present invention is obtained by refolding and then by passing through a reversed phase HPLC RESOURCE RPC column (Amersham Pharmacia Biotech). The physical and chemical properties of the present monomer protein obtained are analyzed on the basis of data of an N-terminal amino acid sequence, an amino acid composition, and electrophoresis.

The biological properties of the monomer protein of the present invention were evaluated by the activity to induce differentiation of two kinds of osteoblast cell lines of which promoting alkaline phosphatase activity was already found in a human MP52 dimer. In comparison in the weight concentration, the monomer protein of the present invention showed a two-fold higher activity than that of the conventional dimer protein.

The present invention relates to a preventive or therapeutic agent for cartilage and/or bone diseases having amino acid sequence represented by SEQ ID NO.: 2 of the Sequence Listing as an effective ingredient. In detail, the monomer protein of the present invention has an activity to induce differentiation, i.e., an morphogenetic activity for cartilage and bone, and therefore, relates to a preventive or therapeutic agent for osteoporosis, congenital bone and/or cartilage diseases, and osteoarthritis such as joint osteoarthritis and hip joint osteoarthritis, or arthroseitis, damage of cartilage such as damage of meniscus, regeneration of bone and cartilage deficit caused by injury and tumor dissection, bone and cartilage deficit, fracture, congenital cartilage and/or bone diseases such as achondroplasia, dyschondrogenesis, achondrogenesis, palatoschisis, and dysosteogenesis, and a deficit of root of teeth and a tooth socket.

Furthermore, the protein of the present invention, having bone and cartilage morphogenetic activity, can be used for therapy of bone graft in an aesthetic surgery field. The therapy includes a field of veterinary surgery.

As in systemic administration method, intravenous, intramuscular, and intra-abdominal administrations are

possible; in an intravenous administration, an intravenous drip can be applied in addition to a general intravenous injection.

An injection preparation can be, for example, a powder preparation for injection. In the case, one or more kinds of appropriate water-soluble excipient such as mannitol, sucrose, lactose, maltose, glucose, or fructose are added to dissolve in water, divided into vials or ampoules, freeze-dried, and hermetically sealed to make as a product.

For a local administration method, there is a method to cover the surface of a cartilage, bone, or tooth of the site with the present protein by using collagen paste, fibrin glue, or other adhesives. Among them, a bone used for bone graft can be also applied to an artificial bone conventionally used as well as a natural bone. The artificial bones include bones made of natural materials or artificial inorganic materials such as metals, ceramics, and glasses. The artificial inorganic materials are preferably exemplified by hydroxyapatite. For example, a metal is used for an internal material and hydroxyapatite for an external material of an artificial bone. Furthermore, the present protein can be administered to a carcinomatous tissue to enhance reconstruction of a bone. It is also possible to use for cartilage grafting.

An administrative dose is determined by a physician in charge in consideration of the following various factors affecting the action of the present protein: the weight of bone and cartilage to reconstruct, the site and condition of the damage of bone and cartilage, sex and age of a patient, severity of the infection, administration duration, and other clinical factors. The dose can vary according to the kind of a carrier used for reconstruction that is realized in combination with the present protein. In general, concerning the dose, ca. 10^{-10} ng as the present monomer protein for a given wet weight of a bone and cartilage in the use as a composition containing a carrier and $0.1-10^4$ μ g for one patient as an injection for local and in systemic application are preferably administered in the frequency ranging from

once a day to once a week.

A multiplier effect can be expected by simultaneous application of a known growth factor such as insulin-like growth factor-I for regeneration of a bone and cartilage.

5 Thus, a monomer made by substitution of cysteine of a protein belonging to TGF- β superfamily and industrial manufacture for a monomer have not been reported. The monomer has a morphogenetic activity for cartilage and bone and is useful as a therapeutic agent for cartilage and/or
10 bone diseases. Furthermore, the monomer protein of the present invention shows a two-fold higher activity per weight than that of a dimer of the protein and allows a half reduction of an effective dose of a therapeutic agent for cartilage and/or bone diseases. This fact can be applied to
15 manufacture of before-mentioned bone morphogenetic factors belonging to TGF- β superfamily.

The monomer protein derived from human MP52 and having an amino acid sequence described in SEQ ID NO.: 2 of the Sequence Listing has a two-fold higher activity in a
20 osteoblast cell line to induce differentiation than that of the dimer and useful as a preventive or therapeutic agent for cartilage and/or bone diseases. Furthermore, a change of an amino acid of the monomer protein of the present invention reduces cysteine and thus, it makes easy preparation of a
25 mass and pure monomer protein possible by using *Escherichia coli*.

EXAMPLES

This invention shall be more illustratively explained by way of the following Examples. The following Examples are to
30 be considered in all respects as illustrative and not restrictive.

Example 1 Preparation of a human MP52 monomer expression vector

(1) Isolation of a mature region of a human MP52 mutant

35 The human MP52 monomer was prepared by replacing cysteine residue which is regarded as forming a dimer with another amino acid residue in order to prevent the formation of a dimer with the human MP52 monomer. In the present

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invention, the codon of cysteine (TGC) of the 83rd of the mature human MP52 starting with proline described in SEQ ID NO.: 1 of the Sequence Listing of WO 96/33215 was converted to the codon of alanine (GCC).

5 The substitution of an amino acid residue was carried out by using a PCR primer (forward direction) in which an objective mutation has been introduced with reference to the mutation method (Section 8.5) by polymerase chain reaction (PCR) described in Current Protocols in Molecular Biology
10 (John Wiley & Sons, Inc.). The sequence of the PCR primer used was described in SEQ ID NO.: 3 as a sense primer and in SEQ ID NO.: 4 as a reverse primer.

PCR was performed by using a human MP52 expression vector (pKOT245) described in WO96/33215 as a template DNA
15 (10 ng), each 10 pM sense primers and reverse primers, dNTP of 0.4 mM, MgCl₂ of 2.5 mM, and LA Taq DNA polymerase (5U, Takara Shuzo Co., Ltd; catalog No. RR013A) in the same test tube. The 30 cycles of reaction was operated of which one cycle included denaturation (94°C, 1 min), primer annealing
20 (55°C, 1 min), and primer elongation (72°C, 2 min). The PCR product was digested by restriction enzymes *Nco*I and *Hind*III, separated by electrophoresis with 1.5% low melting point agarose (FMC BioProducts Co., catalog No. 5170B) and purified to obtain a DNA fragment having a ca. 170 bases as an
25 objective product.

The human monomer MP52 expression vector (pKOT279) was prepared by replacing a DNA fragment of *Nco*I-*Hind*III in which mutation was introduced by aforementioned method with
*Nco*I-*Hind*III region of a human monomer MP52 expression vector
30 (pKOT277) made by modifying a human monomer MP52 expression vector (pKOT245) described in WO96/33215. Concretely, by preparing the human monomer MP52 expression vector (pKOT277) from which lacZ promoter, that is transcribed in the reverse direction to a MP52 existing in the downstream of the
35 terminator of the human monomer MP52 expression vector (pKOT245) described in WO96/33215, by digesting said MP52 expression vector (pKOT277) by restriction enzymes *Nco*I and *Hind*III, separating by electrophoresis in 1.5 % low melting

point agarose (FMC BioProducts Co., cat. No. 5170B) and by purifying, a DNA fragment having 2717 base pairs was obtained for an objective product. The DNA fragment and the DNA fragment of ca. 170 base pairs to which mutation was

- 5 introduced, were ligated by using DNA Ligation Kit (Takara Shuzo Co., Ltd., catalog No. 6021) to prepare a human monomer MP52 expression vector (pKOT279, 2.9 kb). The vector was deposited in National Institute of Bioscience and Human-Technology, Agency of Industrial Science and Technology,
10 Ministry of International Trade and Industry, 1-3, Higashi 1-chome, Tsukuba-shi Ibaraki-ken 305-8566 Japan, in February 5, 1998 (Deposit no. Bikoukenki no. FERM P-16625) and transferred to the International Depository Authority under Budapest Treaty on February 3, 1999 (Deposit No. FERM
15 BP-6637). For the base sequence of the human MP52 monomer expression vector of the present invention, introduction of the objective mutation and correctness of the base sequence (other sequence than that of the site to which a mutation was introduced) of the human MP52 produced were confirmed by
20 using a DNA sequencer (Amersham Pharmacia Biotech, ALF).

(2) Transformation

Transformation was experimented according to rubidium chloride method of Kushner et al. (Genetic Engineering p. 17, Elsevier. 1978). Namely, pKOT279 was introduced to
25 *Escherichia coli* W3110M according to above method to make the *Escherichia coli* to express a protein in the present invention.

Example 2 Cultivation

(1) Cultivation

- 30 The *Escherichia coli* to express a protein of the present invention was precultured in a modified SOC culture medium (Bacto tryptone 20 g/L, Bacto yeast extract 5 g/L, NaCl 0.5 g/L, MgCl₂ 0.95 g/L, and glucose 3.6 g/L), 100 mL of cell suspension (Bacto tryptone 20 g/L, citric acid 4.3 g/L, K₂HPO₄
35 4.675 g/L, KH₂PO₄ 1.275 g/L, NaCl 0.865 g/L, FeSO₄·7H₂O 100 mg/L, CuSO₄·5H₂O 1 mg/L, MnSO₄·nH₂O 0.5 mg/L, CaCl₂·2H₂O 2 mg/L, Na₂B₄O₇·10H₂O 0.225 mg/L, (NH₄)₆Mo₇O₂₄ 0.1 mg/L, ZnSO₄·7H₂O 2.25 mg/L, CoCl₂·6H₂O 6 mg/L, MgSO₄·7H₂O 2.2 g/L,

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thiamine HCl 5.0 mg/L, methionine 2 g/L, and glucose 3 g/L) was added to 5 L of a culture medium for production to culture in a 10 L culture vessel with aerated stirring, isopropyl- β -D-thiogalactopyranoside of 1 mM concentration in a stage reached a logarithmic multiplication prophase (OD₅₅₀=50) was added to culture by OD₅₅₀ beyond 150. In the culture, the temperature was regulated to 31°C and the pH was regulated to 7.2 by adding ammonia. Dissolved oxygen concentration was regulated to 50% of air saturation by increasing stirring speed in order to prevent decrease in dissolved oxygen concentration. A 50% glucose solution containing 0.1 M phosphate was added to make glucose concentration 0.2% with reference to rapid rise of dissolved oxygen concentration as an indication in order to make a higher cell concentration in culture.

(2) Preparation of the inclusion bodies from *Escherichia coli*

The culture solution obtained by said method was passed three times through a high pressure homogenizer (LAB40-10RBF1, APV, Gohrin Co.) under 560 bar pressure to break cells and centrifuge to collect a precipitate containing the inclusion bodies.

Example 3 Purification

(1) Solubilization of the inclusion bodies from *Escherichia coli*

The inclusion bodies collected were washed twice with 20 mM Tris-HCl buffer solution (pH 8.3) containing 1 M urea and 5 mM EDTA and centrifuged at 4°C and 3,000 x g for 30 min; the precipitate obtained was solubilized by sonication in 20 mM Tris-HCl buffer solution (pH 8.3) containing 8 M urea, 50 mM NaCl, 64 mM DTT, and 5 mM EDTA.

(2) Purification of denatured monomer protein

The solubilized solution was centrifuged at 4°C and 20,000 x g for 30 min and the supernatant was collected. The supernatant collected was applied to SP-Sepharose FF (Amersham Pharmacia Biotech) column equilibrated with 20 mM Tris-HCl buffer solution (pH 8.3), 6 M urea, 10 mM DTT, and 1 mM EDTA, washed with the solution, and eluted with the

solution containing 0.4 M NaCl. The eluate was subjected to gel filtration with a Superdex 200 pg column (Amersham Pharmacia Biotech) equilibrated by 20 mM Tris-HCl buffer solution (pH 8.3), 6 M urea, 0.5 M NaCl, 10 mM DTT, and 1 mM EDTA to obtain a single denatured monomer protein.

(3) Refolding

50 mM Na-Glycine buffer solution (pH 9.8), 0.5 M NaCl, 20 mM CHAPS, and 3 mM GSSG (oxidized glutathione) of nine times quantity were added to the solution of the denatured monomer protein obtained by above treatment followed by stirring to refold at 4°C for 20 h.

(4) Purification of a monomer protein having an activity.

The sample refolded was diluted 2.8 times with 14 mM NaH₂PO₄ and subjected to isoelectric precipitation. The precipitate was collected by centrifugation at 3,000 X g for 20 min and dissolved in 0.05% TFA. The solution was applied to a RESOURCE RPC column (Amersham Pharmacia Biotech) of reverse-phase HPLC previously equilibrated with 0.05% TFA and eluted with 0.05% TFA and 0 - 50% acetonitrile gradient. The eluate was monitored by an absorptiometer at 280 nm absorbancy to obtain a fraction of purified monomer protein of the present invention. To the protein fraction, 5 N NaOH was added to make in the range of between pH 6.5 and 7.5 for precipitation in isoelectric point. The precipitate was collected by centrifugation of 10,000 X g for 10 h and dissolved in 10 mM HCl to make ca. 3 mg/mL to obtain a monomer protein having an activity of the present invention.

(i) N-terminal sequence analysis

The N-terminal analysis of the amino acid composition of the purified monomer protein of the present invention obtained above was carried out by using a sequencer (Applied Biosystem, Model 476A).

(ii) Amino acid composition analysis

The amino acid composition of the purified monomer protein of the present invention obtained above was examined by an amino acid analyzer (Waters, PICO. TAG. WORK STATION).

(iii) Electrophoretic analysis

The molecular weight of the purified monomer protein of

the present invention obtained above was investigated by SDS-PAGE under a non-reduced condition to be a molecular weight of ca. 1.4 kDa.

As the results given by (i), (ii), and (iii), it has been found that the monomer protein of the present invention is a monomer protein having 119 amino acid residues of which N-terminal starts with Pro shown in SEQ ID NO.: 2 of the Sequence Listing.

Example 4 Measurement of biological activity

A differentiation inducing activity was evaluated by employing two cultured cell lines; ATDC5 (Riken Gene Bank, RCB 0565) to differentiate like a cartilage cell derived from a mouse embryonic cell and MC3T3-E1 (Riken Gene Bank, RCB 1126) having properties like those of an osteoblast derived from a mouse, on the basis of reference to alkaline phosphatase promoting activity of said protein. The result is shown in Fig. 2.

ATDC5 and MC3T3-E1 of the concentration of 10,000 cells per 1 mL were suspended in DF culture medium (Gibco Ltd.) containing 5% bovine fetus serum and in MEM- α medium (Gibco Ltd.) containing 10% bovine fetus serum, respectively, and inoculated in 24 plates at 1 mL per 1 well to culture at 37°C for 3 days under 5% CO₂.

Subsequently, the cells were rinsed with the MEM- α medium without serum, a natural dimer or a monomer protein diluted gradationally with the MEM- α medium containing 0.3% bovine albumin was added 0.5 mL per 1 well to start induction of differentiation. The cultivation was carried out for 3 days, the cells were rinsed with PBS (20 mM phosphate buffer solution, 150 mM NaCl, pH 7.4) twice and 250 μ L of cytolytic solution (0.2% NP-40, 1 mM MgCl₂) was added and kept standing at 37°C for 2 hours. Following this step, the total volume of the cytolytic solution containing cells broken was transferred to a micro tube and centrifuged (10,000 X g, 5 min) to use its supernatant for assay.

An enzyme activity was measured by observing the rise of absorbancy of p-nitrophenol (pNp) being the dissociated product derived from p-nitrophenyl phosphate as the substrate

of the final concentration of 10 mM by dissolving in 0.1 M glycine buffer, pH 10.4, 1 mM $ZnCl_2$, and 1 mM $MgCl_2$, at 405 nm.

The rise of absorbancy was observed every 2 min for 40 min and the alkaline phosphatase promoting activity (μM pNp/min) was calculated on the basis of the data of the range showing linearity.

In addition, the protein concentration of the same supernatant was known by using a BCA Protein Assay Kit (Amersham Pharmacia Biotech) and the alkaline phosphatase activity per protein was represented by nmol pNp/min/mg protein.

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Sequence Listing Free Text

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<223> Relevant amino acid residues in SEQ ID NO 1 from 1
5 to 82 and from 84 to 119 in WO 95/04819.

Note : aminoacid residue 83 is alanine
instead of cysteine.

<210> 3

10 <223> Sense PCR primer for mutation introducing.

<210> 4

<223> Reverse PCR primer for mutation introducing.

0971131.010001

What is claimed is:

1. A monomer protein comprising an amino acid sequence belonging to TGF- β superfamily, of which cysteine related to
5 a dimer formation of the protein has been replaced with another amino acid.
2. The monomer protein according to claim 1, wherein another amino acid is an amino acid selected from the group consisting of serine, threonine, alanine and valine.
- 10 3. The monomer protein according to claim 1 or 2, wherein another amino acid is alanine.
4. A monomer protein comprising an amino acid sequence described in SEQ ID NO.: 2 of the Sequence Listing.
5. A method for expression by using *Escherichia coli*, a
15 yeast, an insect cell, or a mammal cell transformed with a plasmid comprising a DNA sequence that can express a monomer protein according to any one of claims 1 to 4.
6. An agent comprising the monomer protein according to any one of claims 1 to 4 containing an effective amount of the
20 monomer protein for preventing and treating a disease affecting bone and/or cartilage.
7. The agent for preventing and treating a disease affecting bone and/or cartilage according to claim 6, wherein the disease is osteoporosis.
- 25 8. The agent for preventing and treating a disease affecting bone and/or cartilage according to claim 6, wherein the disease is osteoarthritis or arthroseitis.
9. The agent for preventing and treating a disease affecting bone and/or cartilage according to claim 6, wherein the
30 disease is bone fracture.
10. The agent for preventing and treating a disease affecting bone and/or cartilage according to claim 6, wherein the disease is a lack of root of teeth and a tooth socket.

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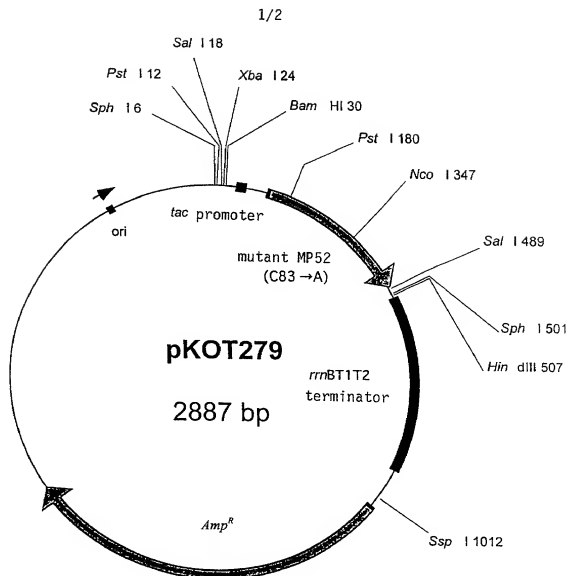


FIGURE 1

2/2

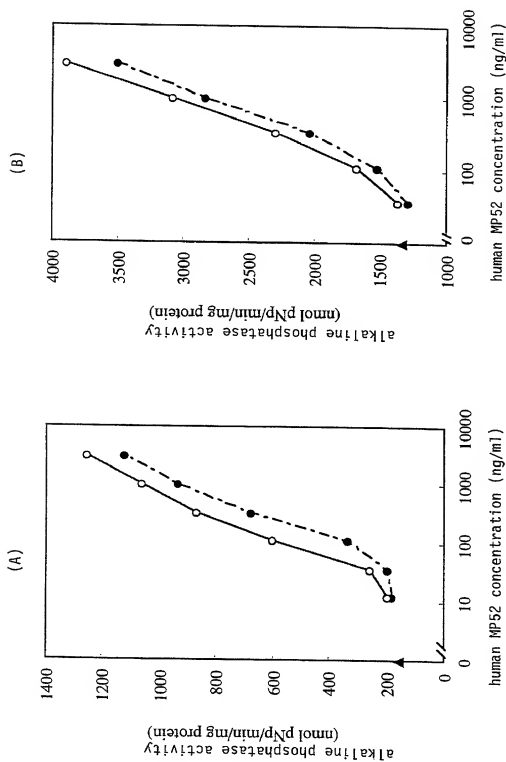


FIGURE 2

SEQUENCE LISTING

<110> Hoechst Marion Roussel

<120> Novel monomer protein with bone morphogenetic activity
and medicinal agent containing the same for preventing
and treating diseases of cartilage and bone.

<130> JH98K008 PCT SEQUENCES IN ENGLISH

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<150> 10-141379

<151> 1998-05-22

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Note : aminoacid residue 83 is alanine
instead of cysteine.

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<301> HOTTEN, Gertrud
NEIDHARDT, Helge
PAULISTA, Michael

<302> New growth/differentiation factor of the tgfbeta
familie.

<310> WO 95/04819

<311> 1995-02-16

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20

25

30

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35

40

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30

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35

40

45

Gly Leu Cys Glu Phe Pro Leu Arg Ser His Leu Glu Pro Thr Asn His

50

55

60

Ala Val Ile Gln Thr Leu Met Asn Ser Met Asp Pro Glu Ser Thr Pro

65

70

75

80

Pro Thr Ala Cys Val Pro Thr Arg Leu Ser Pro Ile Ser Ile Leu Phe

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DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION

☐ Declaration OR ☐ Declaration
Submitted Submitted after
with Initial Filing Initial Filing

Attorney Docket Number	146.1358
First Named Inventor	S. KAWAI et al
COMPLETE IF KNOWN	
Application Number	PCT/IB99/00866
Filing Date	May 14, 1999
Group Art Unit	
Examiner Name	

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

MONOMER PROTEIN WITH BONE MORPHOGENETIC ACTIVITY AND
MEDICINAL AGENT CONTAINING THE SAME FOR PREVENTING AND
TREATING DISEASES OF CARTILAGE AND BONE

(Title of the invention)

the specification of which

☐ is attached hereto

OR

☒ was filed on (MM/DD/YYYY)

May 14, 1999

as United States Application Number or PCT International

Application Number

PCT/IB99/00866

and was amended on (MM/DD/YYYY)

(if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37 Code of Federal Regulations, §1.56

I hereby claim foreign priority benefits under Title 35 United States Code §119 (a)-(d) or §365(b) of any foreign application(s) for patent or inventor's certificate, or §365 (a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached?	
10/141379	Japan	5/22/98	<input type="checkbox"/>	YES	NO
PCT/IB99/00866	IB	5/14/99	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

☐ Additional foreign application numbers are listed on a supplemental priority sheet attached hereto:

I hereby claim the benefit under Title 35, United States Code §119(e) of any United States provisional application(s) listed below.

Application Number(s)	Filing Date (MM/DD/YYYY)	<input type="checkbox"/> Additional provisional application numbers are listed on a supplemental priority sheet attached hereto.

[Page 1 of 5]

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(January 1997)

14.6.1358

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U.S. Parent Application Number	PCT Parent Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number (if applicable)

☐ Additional U.S. or PCT international application numbers are listed on a supplemental priority sheet attached hereto.

As a named inventor, I hereby appoint the following registered practitioner(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

Name	Registration Number	Name	Registration Number
Charles A. Muserlian	19,683		
Jordan B. Bierman	18,629		
Donald C. Lucas	31,275		
Bierman, Muserlian and Lucas	18,818		

☐ Additional registered practitioner(s) named on a supplemental sheet attached hereto.

Direct all correspondence to:

Name	Bierman, Muserlian and Lucas		
Address			
Address	600 Third Avenue		
City	New York	State	New York
Country	U.S.A.	Telephone	(212) 661-8000
		Fax	(212) 661-8002

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name of Sole or First Inventor:		<input type="checkbox"/> A petition has been filed for this unsigned inventor	
Given Name	SHINJI	Middle Initial	
Family Name	KAWAI	Suffix e.g. Jr.	
Inventor's Signature			Date
Residence: City	Paris	State	FR
Post Office Address			
Post Office Address	416, rue Emile Dubois		
City	Paris	State	FR
Zip	75014	Country	France

☒ Additional inventors are being named on supplemental sheet(s) attached hereto

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2#6.1358

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ADDITIONAL INVENTOR(S) Supplemental Sheet

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Given Name	Middle Initial	Family Name	Suffix e.g. Jr.				
MICHIO		KIMURA					
Inventor's Signature			Date				
M. K.			28 November 2000				
Residence: City	State	Country	Citizenship				
Kanagawa		Japan	Japan				
Post Office Address							
9-8-304, Tsurugadai, Chigasaki-shi							
City	State	Zip	Country				
Kanagawa		253-0003	Japan				
Name of Additional Joint Inventor, if any:				<input type="checkbox"/> A petition has been filed for this unsigned inventor			
Given Name	Middle Initial	Family Name	Suffix e.g. Jr.				
YOSHIFUMI		MURAKI					
Inventor's Signature			Date				
Yoshifumi Muraki			28 November 2000				
Residence: City	State	Country	Citizenship				
Tokyo		Japan	Japan				
Post Office Address							
Hoechst Marion Roussel Ltr. Product Realization Dept.							
Post Office Address							
17-51, Akasaka, 2-chome, Minato-ku,							
City	State	Zip	Country				
Tokyo		107-8465	Japan				
Name of Additional Joint Inventor, if any:				<input type="checkbox"/> A petition has been filed for this unsigned inventor			
Given Name	Middle Initial	Family Name	Suffix e.g. Jr.				
MIKO		KATSIURA					
Inventor's Signature			Date				
Miko Katsiura			28 November 2000				
Residence: City	State	Country	Citizenship				
Tokyo		Japan	Japan				
Post Office Address							
2-14-2-106 Sakae-cho, Higashimurayama-shi,							
City	State	Zip	Country				
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City	State	Zip	Country				

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